Computer Programmers

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Significant Points

- Nearly half of all computer programmers held a bachelor's degree in 2002; about 1 in 5 held a graduate degree.

- Employment is expected to grow much more slowly than that of other computer specialists.

- Prospects should be best for college graduates with knowledge of a variety of programming languages and tools; those with less formal education or its equivalent in work experience should face strong competition for programming jobs.

Nature of the Work

Computer programmers write, test, and maintain the detailed instructions, called programs, that computers must follow to perform their functions. They also conceive, design, and test logical structures for solving problems by computer. Many technical innovations in programming—advanced computing technologies and sophisticated new languages and programming tools—have redefined the role of a programmer and elevated much of the programming work done today. Job titles and descriptions may vary, depending on the organization. In this occupational statement, *computer programmer* refers to individuals whose main job function is programming; this group has a wide range of responsibilities and educational backgrounds.

Computer programs tell the computer what to do—which information to identify and access, how to process it, and what equipment to use. Programs vary widely depending upon the type of information to be accessed or generated. For example, the instructions involved in updating financial records are very different from those required to duplicate conditions on board an aircraft for pilots training in a flight simulator. Although simple programs can be written in a few hours, programs that use complex mathematical formulas, whose solutions can only be approximated, or that draw data from many existing systems may require more than a year of work. In most cases, several programmers work together as a team under a senior programmer's supervision.

Programmers write programs according to the specifications determined primarily by computer software engineers and systems analysts. (Separate statements on computer software engineers and on computer systems analysts, database administrators, and computer scientists appear elsewhere in the *Handbook*.) After the design process is complete, it is the job of the programmer to convert that design into a logical series of instructions that the computer can follow. The programmer then codes these instructions in a conventional programming language, such as COBOL; an artificial intelligence language, such as Prolog; or one of the most advanced object-oriented languages such as Java, C++, or Smalltalk. Different programming languages are used depending on the purpose of the program. COBOL, for example, is commonly used for business applications, whereas Fortran (short for "formula translation") is used in science and engineering. C++ is widely used for both scientific and business applications. Many programmers at the enterprise level are also expected to know platform-specific languages used in da-

tabase programming. Programmers generally know more than one programming language and, because many languages are similar, they often can learn new languages relatively easily. In practice, programmers often are referred to by the language they know, as are Java programmers, or the type of function they perform or environment in which they work, which is the case for database programmers, mainframe programmers, or Web programmers.

Many programmers update, repair, modify, and expand existing programs. When making changes to a section of code, called a *routine*, programmers need to make other users aware of the task that the routine is to perform. They do this by inserting comments in the coded instructions, so that others can understand the program. Many programmers use computer-assisted software engineering (CASE) tools to automate much of the coding process. These tools enable a programmer to concentrate on writing the unique parts of the program, because the tools automate various pieces of the program being built. CASE tools generate whole sections of code automatically, rather than line by line. Programmers also utilize libraries of pre-written code, which can then be modified or customized for a specific application. This also yields more reliable and consistent programs and increases programmers' productivity by eliminating some routine steps.

Programmers test a program by running it to ensure that the instructions are correct and that the program produces the desired outcome. If errors do occur, the programmer must make the appropriate change and recheck the program until it produces the correct results. This process is called testing and debugging. Programmers may continue to fix these problems throughout the life of a program. Programmers working in a mainframe environment, which involves a large centralized computer, may prepare instructions for a computer operator who will run the program. (A separate statement on computer operators appears elsewhere in the *Handbook*.) They also may contribute to a manual for persons who will be using the program.

Programmers often are grouped into two broad types—applications programmers and systems programmers. *Applications programmers* write programs to handle a specific job, such as a program to track inventory within an organization. They may also revise existing packaged software or customize generic applications called middleware. *Systems programmers*, on the other hand, write programs to maintain and control computer systems software, such as operating systems, networked sys-
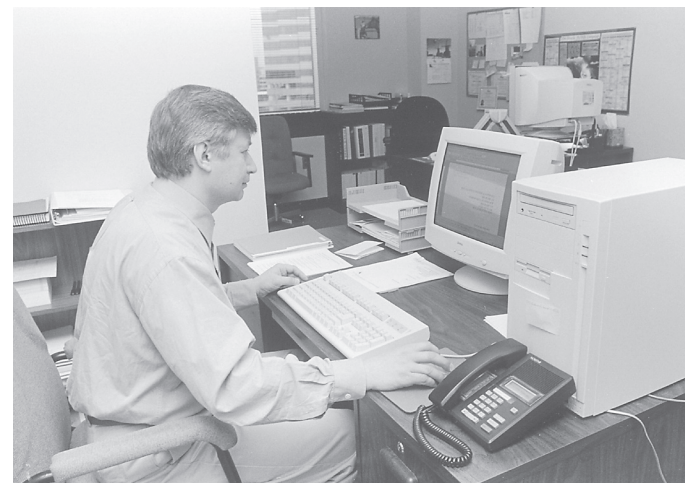
Computer programmers write, test, and maintain the detailed instructions that computers follow.

tems, and database systems. These workers make changes in the sets of instructions that determine how the network, workstations, and central processing unit of the system handle the various jobs they have been given, and how they communicate with peripheral equipment such as terminals, printers, and disk drives. Because of their knowledge of the entire computer system, systems programmers often help applications programmers to determine the source of problems that may occur with their programs.

Programmers in software development companies may work directly with experts from various fields to create software—either programs designed for specific clients or packaged software for general use—ranging from games and educational software to programs for desktop publishing and financial planning. Much of this type of programming takes place in the preparation of packaged software, which constitutes one of the most rapidly growing segments of the computer services industry.

In some organizations, particularly small ones, workers commonly known as *programmer-analysts* are responsible for both the systems analysis and the actual programming work. (A more detailed description of the work of programmer-analysts is presented in the statement on computer systems analysts, database administrators, and computer scientists elsewhere in the *Handbook.*) Advanced programming languages and new object-oriented programming capabilities are increasing the efficiency and productivity of both programmers and users. The transition from a mainframe environment to one that is based primarily on personal computers (PCs) has blurred the once rigid distinction between the programmer and the user. Increasingly, adept end-users are taking over many of the tasks previously performed by programmers. For example, the growing use of packaged software, such as spreadsheet and database management software packages, allows users to write simple programs to access data and perform calculations.

Working Conditions

Programmers generally work in offices in comfortable surroundings. Many programmers may work long hours or weekends to meet deadlines or fix critical problems that occur during off hours. Given the technology available, telecommuting is becoming common for a wide range of computer professionals, including computer programmers. As computer networks expand, more programmers are able to make corrections or fix problems remotely by using modems, e-mail, and the Internet to connect to a customer's computer.

Like other workers who spend long periods in front of a computer terminal typing at a keyboard, programmers are susceptible to eyestrain, back discomfort, and hand and wrist problems, such as carpal tunnel syndrome.

Employment

Computer programmers held about 499,000 jobs in 2002. Programmers are employed in almost every industry, but the largest concentrations are in computer systems design and related services and in software publishers, which includes firms that write and sell software. Large numbers of programmers also can be found in management of companies and enterprises, telecommunications companies, manufacturers of computer and electronic equipment, financial institutions, insurance carriers, educational institutions, and government agencies.

A large number of computer programmers are employed on a temporary or contract basis or work as independent consultants, as companies demand expertise with new programming lan-

guages or specialized areas of application. Rather than hiring programmers as permanent employees and then laying them off after a job is completed, employers can contract with temporary help agencies, consulting firms, or directly with programmers themselves. A marketing firm, for example, may require the services of several programmers only to write and debug the software necessary to get a new customer resource management system running. This practice also enables companies to bring in people with a specific set of skills—usually in one of the latest technologies—as it applies to their business needs. Bringing in an independent contractor or consultant with a certain level of experience in a new or advanced programming language, for example, enables an establishment to complete a particular job without having to retrain existing workers. Such jobs may last anywhere from several weeks to a year or longer. There were 18,000 self-employed computer programmers in 2002.

Training, Other Qualifications, and Advancement

While there are many training paths available for programmers, mainly because employers' needs are so varied, the level of education and experience employers seek has been rising, due to the growing number of qualified applicants and the specialization involved with most programming tasks. Bachelor's degrees are commonly required, although some programmers may qualify for certain jobs with 2-year degrees or certificates. The associate degree is an increasingly attractive entry-level credential for prospective computer programmers. Most community colleges and many independent technical institutes and proprietary schools offer an associate degree in computer science or a related information technology field.

Employers are primarily interested in programming knowledge, and computer programmers can become certified in a programming language such as C++ or Java. College graduates who are interested in changing careers or developing an area of expertise also may return to a 2-year community college or technical school for additional training. In the absence of a degree, substantial specialized experience or expertise may be needed. Even when hiring programmers with a degree, employers appear to be placing more emphasis on previous experience.

Some computer programmers hold a college degree in computer science, mathematics, or information systems, whereas others have taken special courses in computer programming to supplement their degree in a field such as accounting, inventory control, or another area of business. As the level of education and training required by employers continues to rise, the proportion of programmers with a college degree should increase in the future. As indicated by the following tabulation, 65 percent of computer programmers had a bachelor's or higher degree in 2002.

	Percent
High school graduate or equivalent or less	7.7
Some college, no degree	15.2
Associate degree	11.6
Bachelor's degree	48.6
Graduate degree	16.7

Required skills vary from job to job, but the demand for various skills generally is driven by changes in technology. Employers using computers for scientific or engineering applications usually prefer college graduates who have degrees in

computer or information science, mathematics, engineering, or the physical sciences. Graduate degrees in related fields are required for some jobs. Employers who use computers for business applications prefer to hire people who have had college courses in management information systems (MIS) and business and who possess strong programming skills. Although knowledge of traditional languages still is important, employers are placing increasing emphasis on newer, object-oriented programming languages and tools, such as C++ and Java. Additionally, employers are seeking persons familiar with fourth- and fifth-generation languages that involve graphic user interface (GUI) and systems programming. Employers also prefer applicants who have general business skills and experience related to the operations of the firm. Students can improve their employment prospects by participating in a college work-study program or by undertaking an internship.

Most systems programmers hold a 4-year degree in computer science. Extensive knowledge of a variety of operating systems is essential for such workers. This includes being able to configure an operating system to work with different types of hardware and having the skills needed to adapt the operating system to best meet the needs of a particular organization. Systems programmers also must be able to work with database systems, such as DB2, Oracle, or Sybase.

When hiring programmers, employers look for people with the necessary programming skills who can think logically and pay close attention to detail. The job calls for patience, persistence, and the ability to work on exacting analytical work, especially under pressure. Ingenuity, creativity, and imagination also are particularly important when programmers design solutions and test their work for potential failures. The ability to work with abstract concepts and to do technical analysis is especially important for systems programmers, because they work with the software that controls the computer's operation. Because programmers are expected to work in teams and interact directly with users, employers want programmers who are able to communicate with nontechnical personnel.

Entry-level or junior programmers may work alone on simple assignments after some initial instruction, or they may be assigned to work on a team with more experienced programmers. Either way, beginning programmers generally must work under close supervision. Because technology changes so rapidly, programmers must continuously update their knowledge and skills by taking courses sponsored by their employer or by software vendors, or offered through local community colleges and universities.

For skilled workers who keep up to date with the latest technology, the prospects for advancement are good. In large organizations, programmers may be promoted to lead programmer and be given supervisory responsibilities. Some applications programmers may move into systems programming after they gain experience and take courses in systems software. With general business experience, programmers may become programmer-analysts or systems analysts or be promoted to a managerial position. Other programmers, with specialized knowledge and experience with a language or operating system, may work in research and development on multimedia or Internet technology, for example. As employers increasingly contract out programming jobs, more opportunities should arise for experienced programmers with expertise in a specific area to work as consultants.

Certification is a way to demonstrate a level of competence, and may provide a jobseeker with a competitive advantage. In addition to language-specific certificates that a programmer can obtain, product vendors or software firms also offer certification and may require professionals who work with their products to be certified. Voluntary certification also is available through other various organizations.

Job Outlook

Employment of programmers is expected to grow about as fast as the average for all occupations through 2012. Jobs for both systems and applications programmers should be most plentiful in data processing service firms, software houses, and computer consulting businesses. These types of establishments are part of computer systems design and related services and software publishers, which are projected to be among the fastest growing industries in the economy over the 2002-12 period. As organizations attempt to control costs and keep up with changing technology, they will need programmers to assist in conversions to new computer languages and systems. In addition, numerous job openings will result from the need to replace programmers who leave the labor force or transfer to other occupations such as manager or systems analyst.

Employment of programmers, however, is expected to grow much more slowly than that of other computer specialists. With the rapid gains in technology, sophisticated computer software now has the capability to write basic code, eliminating the need for more programmers to do this routine work. The consolidation and centralization of systems and applications, developments in packaged software, advances in programming languages and tools, and the growing ability of users to design, write, and implement more of their own programs means that more of the programming functions can be transferred from programmers to other types of workers. Furthermore, as the level of technological innovation and sophistication increases, programmers are likely to face increasing competition from programming businesses overseas, to which much routine work can be contracted out at a lower cost.

Nevertheless, employers will continue to need programmers who have strong technical skills and who understand an employer's business and its programming requirements. This means that programmers will have to keep abreast of changing programming languages and techniques. Given the importance of networking and the expansion of client/server, Web-based, and wireless environments, organizations will look for programmers who can support data communications and help to implement electronic commerce and Intranet strategies. Demand for programmers with strong object-oriented programming capabilities and technical specialization in areas such as client/server programming, wireless applications, multimedia technology, and graphic user interface (GUI) should arise from the expansion of intranets, extranets, and Internet applications. Programmers also will be needed to create and maintain expert systems and embed these technologies in more products. Finally, growing emphasis on cyber-security will lead to increased demand for programmers who are familiar with digital security issues and skilled in using appropriate security technology.

As programming tasks become increasingly sophisticated and additional levels of skill and experience are demanded by employers, graduates of 2-year programs and people with less than a 2-year degree or its equivalent in work experience should face strong competition for programming jobs. Competition for entry-level positions, however, also can affect applicants with a bachelor's degree. Prospects should be best for college graduates with knowledge of, and experience working with, a variety

of programming languages and tools—including C++ and other object-oriented languages such as Java, as well as newer, domain-specific languages that apply to computer networking, database management, and Internet application development. Obtaining vendor-specific or language-specific certification also can provide a competitive edge. Because demand fluctuates with employers' needs, jobseekers should keep up to date with the latest skills and technologies. Individuals who want to become programmers can enhance their prospects by combining the appropriate formal training with practical work experience.

Earnings

Median annual earnings of computer programmers were $60,290 in 2002. The middle 50 percent earned between $45,960 and $78,140 a year. The lowest 10 percent earned less than $35,080; the highest 10 percent earned more than $96,860. Median annual earnings in the industries employing the largest numbers of computer programmers in 2002 were:

Professional and commercial equipment and supplies merchant wholesalers	$70,440
Software publishers	66,870
Computer systems design and related services	65,640
Management of companies and enterprises	59,850
Data processing, hosting, and related services	59,300

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer programming averaged $45,558 a year in 2003.

According to Robert Half International, a firm providing specialized staffing services, average annual starting salaries in 2003 ranged from $51,500 to $80,500 for applications development programmers/analysts, and from $55,000 to $87,750 for software developers. Average starting salaries for mainframe systems programmers ranged from $53,250 to $68,750 in 2003.

Related Occupations

Other professional workers who deal extensively with data include computer software engineers; computer systems analysts, database administrators, and computer scientists; statisticians; mathematicians; engineers; financial analysts and personal financial advisors; accountants and auditors; actuaries; and operations research analysts.

Sources of Additional Information

State employment service offices can provide information about job openings for computer programmers. Municipal chambers of commerce are an additional source of information on an area's largest employers.

Further information about computer careers is available from:
➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**
➤ Institute of Electrical and Electronics Engineers Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**
➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**